

# Diet of the Broad-toothed Rat *Mastacomys fuscus* (Rodentia:Muridae) in the alpine zone of the Snowy Mountains, Australia

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## ABSTRACT

In seasonally snow-covered environments, larger mammalian species occurring above the snow have been shown to broaden diet breadth in winter, but below the snow in the subnivean space the relationship between snow cover and diet is quite different. The Broad-toothed Rat *Mastacomys fuscus*, an Australian cold climate endemic, is a specialist herbivore. The diet of *M. fuscus* in the alpine zone of the Snowy Mountains was studied over the snow-free period and in winter. *M. fuscus* showed a preference for monocots over dicots throughout the year, however, there was a greater diversity and evenness of plant taxa in the diet in snow-free seasons. In winter, fewer species dominated the diet, reducing the evenness as well as the diversity. Because of lack of cover from predators in the snow-free period, *M. fuscus* is constrained to foraging in areas with shrub cover, where access to preferred grasses may be reduced. By contrast, in the subnivean space, because of the shelter provided by the cover of snow, *M. fuscus* can build temporary above-ground grass nests and concentrate its foraging in areas of grassland which, in summer, provide no cover from predators. The fact that it is able to collect an excess of preferred *Poa* spp. sufficient to build nests, and these, together with assorted piles of grass and grass cut to lie in runways are discarded after winter suggests that in winter food availability is not limited.

**Key words:** snow, subnivean space, European hare, diet breadth

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## Introduction

The Broad-toothed Rat *Mastacomys fuscus*, an Australian cold climate endemic, is considered to be a southern hemisphere ecological equivalent of northern hemisphere voles such as *Clethrionomys* and *Microtus*. It is morphologically similar, has delayed maturity, a similar diet of grass, and occupies similar terrain where a network of runways link refuges such as substantial above-ground nests of dried grass (Calaby and Wimbush 1964, Happold 1989a, Breed and Ford 2007). With the introduction of European Red Foxes *Vulpes vulpes* to Australia, similarities between these northern and southern hemisphere species even extend to predation: both voles and *M. fuscus* are preferred over murine rodents as prey (Macdonald 1977, Green 2002). However, there are differences between *M. fuscus* and these northern hemisphere rodents: its populations do not vary in cycles, subnivean breeding (continuous reproduction under snow) does not occur, it is larger and survival rates are higher (Happold 1989a). Additionally, it does not undergo autumnal mass reduction (Happold 1989a), an adaptation to seasonally snow-covered environments found in the sympatric marsupial Dusky Antechinus *Antechinus swainsonii*, as well as northern hemisphere rodents and insectivores (Green 2001).

*Mastacomys fuscus* is distributed from Tasmania to the Barrington Tops (NSW) and from sea level to > 2200 m in elevation with the highest densities recorded above the winter snowline (1500 m elevation in NSW) for a number

of reasons, possibly including competition with Swamp Rats *Rattus lutreolus* or habitat degradation by introduced hard hoofed animals and/or European Rabbits *Oryctolagus cuniculus* at lower altitudes (Green and Osborne 2003, Green *et al.* 2008). Its range is characterized by high rainfall and low temperatures (Green and Osborne 2003). At subalpine altitudes it inhabits areas with a moderate-to-dense ground cover of grasses or sedges with shrubs usually present, particularly along valley floors near to streams (Happold 2008). The most common alpine sites used are adjacent to grassland around boulders either in tors or boulder fields, beneath dry heath dominated by *Nematolepis ovatifolia* (previously *Phebalium ovatifolium* in Costin *et al.* 2000), or wet heath (Green and Osborne 2003). In winter it may also move into open grassland once the subnivean space has developed (the space between the snow and the ground surface) and this is facilitated by the use of temporary ground-surface grass nests (Green and Osborne 2003).

The limited amount of work on the diet of *M. fuscus* is generally descriptive and suggests it is one of the most herbivorous of Australian rodents (Carron *et al.* 1990, Breed and Ford 2007). Stomach contents of a small sample of *M. fuscus* collected as specimens from low elevations in Tasmania consisted of monocot material, mainly sedge with some grass and dicot material (Green 1968), with grass also reported dominating two stomach samples from the

Snowy Mountains (Watts 1977). The only detailed study of the diet was undertaken seasonally in the subalpine zone of the Snowy Mountains over the course of a year, where it was concluded that *M. fuscus* was a specialist herbivore, consuming mainly monocot leaf with dicot leaf next most common and bark, seed and fungi occurring as relatively minor constituents of the diet (Carron *et al.* 1990). Monocotyledons dominated the diet throughout the year with dicotyledon leaf peaking in spring and autumn (Carron *et al.* 1990). However, like the earlier studies of the diet of *M. fuscus*, the study by Carron *et al.* (1990) examined diet at broad taxonomic resolution only and there are currently no published data on the plant species consumed by *M. fuscus*, nor any data on its diet at higher altitudes. *Mastacomys fuscus* is active throughout the year but does not cache hay in summer and hence needs to forage through winter in the subnivean space. It does collect grass to build nests once snow covers the ground (pers. obs., Happold 1989a) and, as with the Meadow Vole *Microtus pennsylvanicus* (Courtin *et al.* 1991), *M. fuscus* may use this nesting material for food when foraging becomes difficult. However, no information is available on seasonal variation in the diet of *M. fuscus* in the alpine zone to provide insight into such behaviour.

The primary aim of the present study was to provide a detailed description of the diet of *M. fuscus* in the alpine zone by examining diet at high taxonomic resolution based on widespread sampling across the alpine zone of the Snowy Mountains. *Mastacomys fuscus* is a large animal with respect to foraging in the subnivean space and so the second aim was to compare the diet of *M. fuscus* among seasons to examine the constraints of foraging beneath the snowpack and to understand how it survives in alpine conditions where foraging distance could be expected to be constrained by seasonal snow cover.

## Methods

### Faecal sample collection

*Mastacomys fuscus* eats 50–70 % of its body mass each day (Happold 2008), producing 200–400 faecal pellets which survive intact for up to five years. The faecal pellets are quite characteristic of *M. fuscus* and distinct from all other species in the alpine zone (Happold 1989b). They are green when fresh and fade to a pale straw-colour as they age, although it is not possible to determine their exact age based on their appearance (Green 1968, Happold 1989b). We used faecal pellets from free-ranging *M. fuscus* for diet analysis rather than pellets collected during trapping so as to cover a wider range of habitat types across the alpine zone without the need for a widespread trapping effort. Faecal pellets were collected over the snow-free period from January to May 2012. Although we could not age pellets precisely, by collecting fresh pellets only we were able to ensure that the pellets could be ascribed to four broad sub-seasons within the snow-free period: early and late summer (January–March), early and late autumn (April–late May). Spring was not represented in our sampling because pellets under snow retain their green and moist condition longer than when exposed to the sun and hence newly uncovered winter scats and spring scats

can be confused. To ensure collection of a winter sample, as the snow thawed in October 2012, newly revealed faecal piles were investigated and where the surface scats were bleached by the sun, underlying greener scats were collected. Because samples were collected from natural conditions rather than from traps they may have been contaminated by fungus, hence fungal spores were not searched for in the pellets although fungus may constitute a part of the diet.

### Microhistological diet analysis

Faecal pellet samples, along with a reference herbarium of plant species that occur in the alpine zone of the Snowy Mountains (plant names following Costin *et al.* 2000), were prepared for microhistological analysis following Norbury (1988), with some modifications described in Green *et al.* (2013). Briefly, 10 mL portions of each sample were digested in 4 % sodium hypochlorite for 3 h then a sub-sample was rinsed, stained and mounted on a microscopic slide.

To determine the proportion of each category of plant epidermal fragments in dietary samples, point quadrat analysis was used (Norbury 1988, Green *et al.* 2013) with 100 fragments identified per slide, following Katona and Althacker (2002) and Carron *et al.* (1990). Where possible, fragments were identified to family, genus and species.

### Vegetative composition of nests

To determine the utility of nests as a fallback food supply, plant material from 10 nests of *M. fuscus* was collected after the 2013 snow thaw. Sampling was from the top half of the (usually flattened) nest so as to avoid, where possible, plant material that had been cut by *M. fuscus in situ* and thereby maximize sampling of material that had been selected and transported to the site. Plant species in runways leading to nests that had been cut by *M. fuscus* and generally left on the ground in the runway were recorded. Nest material was placed in paper bags and allowed to dry for several weeks at air-conditioned room temperature (c 20°C). The total nest material was weighed when dry, spread on a dry paper surface and sorted according to species by eye or by later microscopic identification and all vegetation components weighed.

### Data analysis

To assess seasonal variation in diet, we compared the diversity and composition of the vegetation taxa identified in the scats of *M. fuscus* between the winter and the pooled snow-free period samples. The species richness, Pielou's species evenness, and Simpson diversity index were calculated for each pellet sample and the average for winter and the snow-free period compared using Satterthwaite's approximate *t* test. We used Satterthwaite's approximation because the sample sizes were noticeably unequal when the snow-free period samples were pooled and the robustness of the *t* test to subsequent potential violations of the assumption of homogeneity of variances is improved with this correction (Zar 2007). These three measures were also compared between winter and the four sub-seasons within the snow-free period, using a single factor ANOVA. When a significant overall effect among the five time

periods was found, the means were compared across all pairwise combinations using Scheffe corrections for type 1 error. The average Bray-Curtis similarity of the composition of the pellets in winter and summer periods was tested using PERMANOVA (Anderson 2001), and the multivariate dispersion between the seasons compared using PERMDISP (Anderson 2005). Similarities were calculated on square root transformed relative frequencies (%) of the abundance of each vegetation taxon in the pellets. Follow up pairwise PERMANOVA and PERMDISPs compared the compositional similarity and multivariate dispersion of pellet composition in winter and all four snow-free period sub-seasons. All tests were based on 10,000 permutations of the raw data. The pellets were ordinated using non-metric multi-dimensional scaling and are presented along with those taxa that had principal ordination axis rank correlations greater than 0.5. All univariate statistics and tests were performed in SAS (SAS 2009) and multivariate analyses in e-primer (Clarke and Gorley 2006).

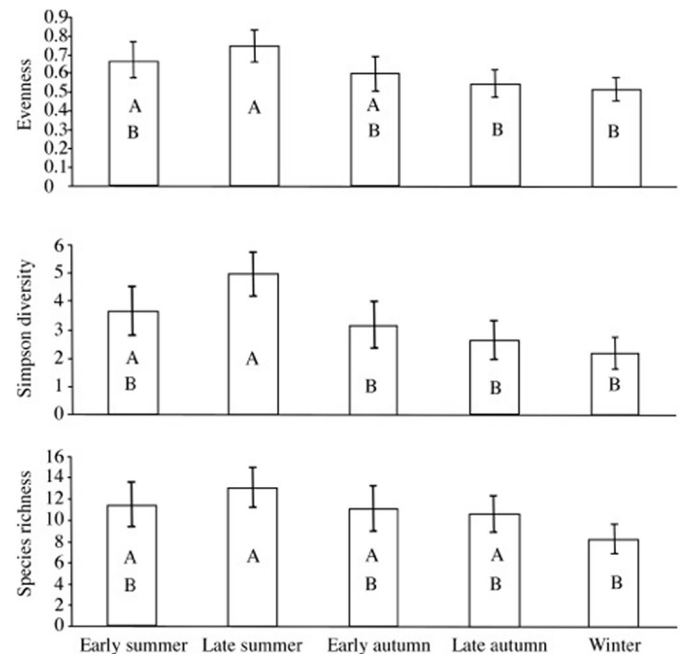
## Results

A minimum of 59 plant species was consumed by *M. fuscus*, 56 in snow-free months and 41 in winter (Appendix 1). The proportion of grass in the diet increased through the sample periods from summer reaching a maximum in winter when shrub intake was also maximal (Table 1). This was accompanied by a decrease in the amount of rushes and sedges in the diet (Table 1). Herbs peaked in the diet in late summer (Table 1). *Poa* spp. inflorescences occurred in 20 % of early summer samples and seed, fruit and/or flower material occurred on average in  $44 \pm 6$  % (SD) of samples from late summer to winter (Table 1). Seed/flower heads of *Celmisia* spp. constituted 53 % of these occurrences and vegetative material from *Celmisia* sp. was also recorded in most (75 %) of these samples.

Pellets of *M. fuscus* had a higher species richness and had a higher taxonomic diversity in summer/autumn than in winter ( $T_{\text{richness}} = 4.6$ ,  $df = 67$ ,  $p < 0.0001$ ;  $T_{\text{Simpson}} = 4.6$ ,  $df = 73$ ,  $p < 0.0001$ ). On average there were 11.5 plant taxa identified per pellet in summer/autumn compared with 8.2 in winter. The evenness of the plant taxa in pellet samples differed between the seasons ( $T_{\text{evenness}} = 3.2$ ,  $df = 61$ ,  $p < 0.003$ ) being 23 % more even (Pielou's  $J = 0.64$ ) in summer/autumn than in winter ( $J = 0.52$ ). All three univariate measures were significantly different among the five collection periods ( $F_{\text{richness}} = 5.1$ ,  $df = 4, 70$ ,  $p < 0.002$ ;

$F_{\text{evenness}} = 5.7$ ,  $df = 4, 70$ ,  $p < 0.0005$ ;  $F_{\text{Simpson}} = 9.9$ ,  $df = 4, 70$ ,  $p < 0.0001$ ). All three measures were highest in late summer and significantly lower in winter (Figure 1).

There was a significant difference in the composition of plant species in pellet samples collected during winter and the snow-free period (PERMANOVA Pseudo  $F = 4.8$ ,  $df = 1, 73$ ,  $p < 0.0002$ ). The multivariate dispersion of the samples was greater in the snow-free period (Mean Bray-Curtis distance to centroid = 37 %) than in winter (32 %) (PERMDISP  $F = 6.1$ ,  $df = 1, 73$ ,  $p = 0.023$ ). There was a significant difference in average Bray-Curtis similarity among the four snow-free period sub-seasons and winter (PERMANOVA Pseudo  $F = 3.6$ ,  $df = 4, 70$ ,  $p < 0.0001$ ). Pellet composition in early summer was significantly different to all other time periods ( $p < 0.05$ ) and winter was different to all sub-seasons ( $p < 0.05$ ) except early autumn ( $p < 0.10$ ) (Table 2).



**Figure 1.** Mean ( $\pm$  95 % confidence interval) evenness, Simpson diversity and plant species richness in pellets of *M. fuscus* in early and late summer and autumn and in winter. Seasons with the same letter are not significantly different after Scheffe correction for Type I error.

**Table 1.** Percentage occurrence of plant functional groups in the diet of *Mastacomys fuscus* in early and late summer and autumn, and winter, together with the frequency of occurrence of seed/fruit/flower material in pellet samples.

	Early Summer	Late Summer	Early Autumn	Late Autumn	Winter
Grass	66.7	61.6	75.4	72.3	82.3
Herb	11.0	24.8	14.2	15.9	7.9
Shrub	4.5	2.7	4.1	3.4	6.9
Rush/Sedge	17.7	10.6	6.1	7.9	2.6
Fern	0.0	0.2	0.1	0.3	0.0
Bryophyte	0.1	0.2	0.2	0.1	0.4
Seed/Fruit/Inflorescences	20	46	36	50	44

**Table 2.** Bray-Curtis percentage similarity in vegetative composition of pellets of *M. fuscus* collected in early and late summer and autumn, and winter. The diagonal values are the within time period similarities.

	Early Summer	Late Summer	Early Autumn	Late Autumn	Winter
Early Summer	40				
Late Summer	43*	52			
Early Autumn	41**	52	54		
Late Autumn	37**	49**	52	52	
Winter	37**	46**	53^	51*	54

^  $p < 0.10$ , \*  $p < 0.05$ , \*\*  $p < 0.005$ .

The multivariate dispersion of the samples was greater in early summer (mean Bray-Curtis distance to centroid = 41 %) than all other time periods (all in the range of 31 - 33 %), however the difference was not quite statistically significant (PERMDISP  $F = 2.6$ ,  $df = 4, 70$ ,  $p = 0.07$ ). The increased variability in summer pellets and their tendency to be positioned away from the other seasons can be observed in the ordination (Figure 2). The pellets collected in early and late summer were associated with *Festuca rubra*, and pellets collected in autumn and winter were more associated with *Poa* spp. (Figure 2). *Nematolepis ovatifolia* was more common in autumn than summer pellets, and in winter than autumn pellets, whilst the opposite was true for *Oreobolus distichus* (Figure 2).

The collected nest material averaged  $51.5 \pm 23.6$  g dry mass and was dominated by *Poa* spp. (mainly identified as *P. costiniana* and/or *P. fawcettiae*) which constituted  $96.3 \pm 4.3$  % of the nest material. The remainder included stems of a broad-leaved grass, *Empodisma minus*, *Lycopodium fastigiatum*, unidentified fern, small pieces of unidentified shrub stem, leaves of the shrub *N. ovatifolia* and generally unidentified material. In runways leading to the nests the following plants had been cut by a rodent, presumably *M. fuscus*: *Poa* spp., *N. ovatifolia*, *E. minus* and unidentified

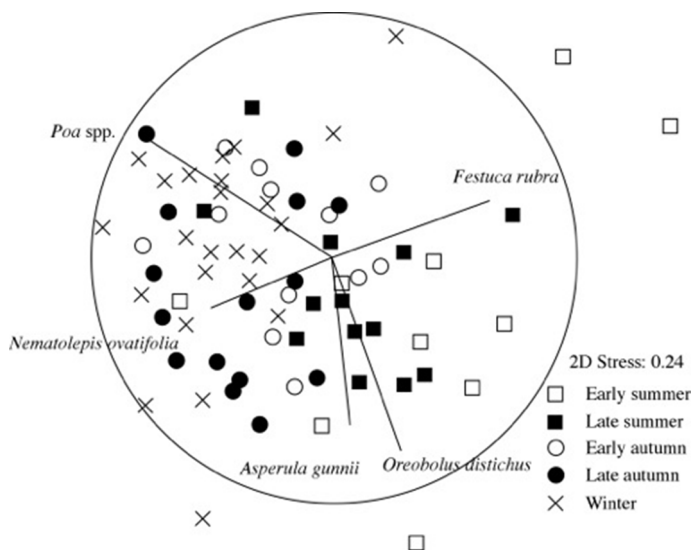
fern, all of which were also found in nest material and *Celmisia* sp. and *Olearia phlogopappa* that were not in the nest material but did appear in the diet and *Pimelea* sp., *Orites lancifolia* and *Podocarpus lawrencei* that did not appear in nest material nor in the diet.

## Discussion

### Seasonal changes in diet

At a broad level, the diet of *M. fuscus* in the alpine zone varied little between snow-free seasons and winter with respect to consumption of monocots 79.6 v 85 % and dicots 20.3 v 14.7 %. At subalpine Smiggin Holes there was also little seasonal variation in the diet of *M. fuscus*: in summer/autumn monocots constituted 69.9 % of the diet while in winter they constituted 68.7 %, with dicots making up 24 and 26 % of the diet respectively (Carron et al. 1990). Carron et al. (1990) found 'little evidence of seasonal opportunism in the types of food eaten'. They, however, did not have the advantage of species identification and referred to all monocots throughout the text as 'grass', whereas in the present study we found a change at the species level from the monocots of summer, comprising sedges *Carex* spp. and non-native grasses *Agrostis* sp., *Dactylis glomerata*, and *Festuca* sp., which declined through summer and autumn and were replaced by the grasses *Poa costiniana* and *Poa hiemata*. As well as a reduction in sedges, there was also a decrease in the amount of rushes in the diet, which may be due to a move in foraging away from wetter areas as autumn rains made these less habitable.

Despite changes in the species composition of the monocot material eaten, there was no major shift in the diet of *M. fuscus* away from grass through the seasons. Some grasses decreased in proportion of the diet across the seasons while others increased. Interestingly, in the same alpine area the genus (*Poa*) that decreased in the diet of European Hares *Lepus europaeus* during autumn, presumably due to reduction in palatability of grasses post-seeding (Green et al. 2013), was the very one that increased in the diet of *M. fuscus* during autumn. The herb *Oreomyrrhis eriopoda* only appeared in any substantial amount in the diet during early summer. As this and the rushes and sedges declined there was an overall increase in herbs taken, with *Wahlenbergia* sp. being common only in late summer while *Asperula* sp., *Senecio* sp. and *Celmisia* sp. continued their importance through to autumn. *Celmisia* sp. was mostly eaten whilst it was setting seed, and in fact *M. fuscus* collected and cached piles of *Celmisia*



**Figure 2.** Ordination based on Bray-Curtis similarity of square root transformed relative abundances of vegetation taxa identified in pellets of *M. fuscus*. Plant taxa with Spearman correlation with the ordination space  $> 0.5$  are represented by vectors showing the direction of the correlation and the circle represents a correlation of 1.0.



flower heads along their runways at this time (KG pers. obs.). The only shrub important in the diet, *N. ovatifolia*, was most commonly taken in winter, increasing from 1.1 % of the diet in summer to 4.9 % in winter. This species and *Prostanthera cuneata* were both highly conspicuous in the diet of *M. fuscus* at Smiggin Holes, and were partially defoliated at the end of winter (Carron *et al.* 1990). *Prostanthera cuneata* was not common in the diet in the alpine zone and was not seen to be gnawed. However, there was much evidence of depredation of *N. ovatifolia* in the present study, particularly with evidence of gnawing on the bark at the base of stems, and signs of browsing particularly at the end of shoots that were pushed closer to the ground by snow.

### The influence of snow cover on diet

There is a minimum size necessary for mammals to be able to tolerate thermal conditions above the snow surface and a maximum size to be able to forage beneath the snow within the restrictive environment of the subnivean space (Green 1998). In the Snowy Mountains, *L. europaeus* (grazers and open grassland specialists) and *M. fuscus* occupy these two poles. *Mastacomys fuscus* is large for a subnivean-active species with an adult mass of 120–170 g compared with <35 g for northern hemisphere subnivean species such as the Long-tailed Vole *Microtus longicaudus* (Spencer 1984) and Red-backed Vole *Clethrionomys gapperi* (Merritt 1984). Larger animals are more constrained in their subnivean foraging because of the constraints of space (Spencer 1984) and the subnivean space may also contain inaccessible patches of vegetation, further reducing access to food resources (Korslund and Steen 2006). However, it has been suggested that the size of small mammals must have been influenced by the size of the subnivean space (Coulianos and Johnels 1962). In the Snowy Mountains the subnivean space is formed by protection under shrubs and melting at the soil-snow interface (Green and Osborne 2012). Temperature gradient metamorphism leading to depth hoar, as found in boreal climates, which produces a smaller subnivean space, does not occur (Sanecki *et al.* 2006). Therefore the subnivean space is generally greater than in the northern hemisphere. Of the two plant communities occupied by *M. fuscus* in the alpine zone, dry heath has a subnivean height of approximately 150 mm with grassland being more restrictive with 80 mm (Green and Sanecki 2006). This is, however, sufficient to allow the relatively large *M. fuscus* to utilize the resources in this habitat that are not available to the larger (c 3.5 kg) *L. europaeus*. Hence, a comparison of the diet of *M. fuscus* with that of *L. europaeus* highlights the constraints on movement and feeding for a herbivore either moving beneath the snow or moving on the snow surface.

In the alpine zone of the Snowy Mountains, grasses were the main item in the diet of *L. europaeus* in summer at c 70 %, declining to 47 % in autumn when herbs were co-dominant in the diet, and 28 % in winter when shrubs dominated at 43 % compared with a maximum of 3 % in snow-free months (Green *et al.* 2013). This dietary switch to taller shrubs occurred because the ground vegetation was largely unavailable due to snow cover except in windswept feldmark where some herbs and grasses were

available. In this situation *L. europaeus* had to expand its dietary breadth to cope with limited resource availability under harsh conditions, including selecting a wider range of plant species in winter than in summer. At subalpine Smiggin Holes, radiotelemetry revealed spatially restricted winter movement and a low level of activity by *M. fuscus* (Bubela *et al.* 1991). However, in contrast to *L. europaeus*, *M. fuscus* had an expanded dietary breadth in the alpine zone in summer/autumn with a higher species richness and higher taxonomic diversity than in winter. This suggests two possible effects of snow cover on winter foraging by *M. fuscus*. It is possible that *M. fuscus* was constrained in its foraging in winter by snow cover to areas that had lower plant diversity; this is supported by the lower number of species (8.2 v 11.5) identified per pellet in winter compared to summer/autumn with a more even distribution in pellets. However, the use of the protected subnivean space by *M. fuscus* enables it to use open grasslands in winter that are not habitable in summer and, by establishing temporary grass nests in winter, it is able to gain access to abundant palatable resources that are not normally available under shrub cover. Therefore it does not need to broaden its dietary niche during winter because there is no food shortage to overcome.

Unlike many northern hemisphere rodents inhabiting areas with seasonal snow cover, *M. fuscus* does not collect grass for winter nests/food until after the snow cover has established. This suggests that it has little trouble accessing these resources in winter. Plant material is cut and left along the length of runways, perhaps as insulation in a similar way to *M. longicaudus* that use such plant material to line their burrows (Spencer 1984). This material differs from that which is used to construct nests, which is mainly *P. costiniana* and/or *P. fawcettiae*, two species which together make up 45 % of the winter diet. Whether *M. fuscus* uses this nesting material for food in winter when collapse or flooding of the subnivean space or blockages due to ice formation make foraging difficult is unknown. However, the major food resource, either *in situ* or as stored in grass piles is obviously available in sufficient quantity for *M. fuscus* neither to lose weight in winter nor to cause low winter survival (Happold 1989a).

The diets of *M. fuscus* and *L. europaeus* highlight the differing ways in which the constraints of foraging with deep seasonal snow cover are overcome by species of differing body size. *Lepus europaeus* forages on preferred species in the snow-free period, but in winter is constrained to those species that either project above the snow (shrubs) or are exposed by the wind. Thus winter survival requires an ability to range widely and to increase dietary breadth to include unpalatable food resources. *Mastacomys fuscus* by contrast is constrained in its summer foraging to areas of shrub cover. Although subnivean space is greater under shrubs than in grassland it does not remain there in winter and expand its dietary breadth. Instead, because of the shelter provided to small mammals by snow cover in the form of the subnivean space, *M. fuscus* can forage in winter in areas which, in summer, provide no cover from predators. This means it can access areas of open grassland that it cannot graze in summer and possibly access preferred grasses that are also less available in summer.



**Figure 3** In open grassland, a habitat not used in summer, *Mastacomys fuscus* constructs grass-lined runways and grass piles that are made from material that is not collected until after snow covers the ground. Grass piles were dominated by *Poa costiniana* and/or *P. fawcettiae* which together make up 45 % of the winter diet.

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## APPENDIX I

**Appendix I.** Average percentage composition of the diet of *Mastacomys fuscus* in periods with and without snow cover: Life forms are Shrub, Herb, Grass, Sedge, Rush, Fern and Bryophyte

Species	Life Form	Mono/dicot	Summer/Autumn	Winter
Monocot (Total)			79.6	85.0
Dicot (Total)			20.3	14.7
Bryophyte (Total)			0.10	0.36
<i>Acetosella vulgaris</i>	H	D	0.18	0.00
<i>Aciphylla</i> sp.	H	D	3.10	1.24
<i>Agrostis</i> sp.	G	M	2.98	3.20
<i>Asperula</i> sp.	H	D	3.34	1.40
<i>Australopyrum velutinum</i>	G	M	0.20	0.00
<i>Baeckea</i> sp.	S	D	0.14	0.00
<i>Brachyscome scapigera</i>	H	D	0.16	0.12
<i>Brachyscome spathulata</i>	H	D	0.02	0.00
<i>Carex gaudichaudiana</i>	Se	M	1.74	0.04
<i>Carex hebes</i>	Se	M	3.52	0.68
<i>Celmisia</i> sp.	H	D	3.00	3.32
<i>Chionochloa frigida</i>	G	M	1.98	6.24
<i>Craspedia</i> sp.	H	D	0.08	0.04
<i>Dactylis glomerata</i>	G	M	5.16	1.84
<i>Deyeuxia carinata</i>	G	M	0.30	0.28
<i>Dianella tasmanica</i>	H	D	0.02	0.00
<i>Diplaspis nivis</i>	H	D	0.02	0.00
<i>Empodisma minus</i>	R	M	0.36	0.56
<i>Epilobium gunnianum</i>	H	D	0.70	0.16
<i>Euphrasia collina</i>	H	D	0.10	0.00
<i>Ewartia nubigena</i>	H	D	0.02	0.04
<i>Festuca rubra</i>	G	M	11.50	6.88
<i>Geranium</i> sp.	H	D	0.08	0.04
<i>Grevillea australis</i>	S	D	0.02	0.00
<i>Hypochaeris radicata</i>	H	D	0.14	0.04
<i>Leptorhynchus squamatus</i>	H	D	0.02	0.00
<i>Luzula</i> sp.	R	M	0.00	0.12
<i>Lycopodium fastigiatum</i>	B		0.12	0.36
<i>Melicytus</i> sp.	S	D	1.28	0.88
<i>Microseris lanceolata</i>	H	D	0.10	0.00
<i>Nematolepis ovatifolia</i>	S	D	1.08	4.92
<i>Neopaxia australasica</i>	H	D	0.46	0.12
<i>Olearia algida</i>	S	D	0.06	0.00
<i>Olearia phlogopappa</i>	S	D	0.38	0.36
<i>Oreobolus distichus</i>	Se	D	4.56	1.16
<i>Oreomyrrhis</i> sp.	H	D	1.08	0.00
<i>Oxylobium ellipticum</i>	S	D	0.00	0.04
<i>Ozothamnus alpinus</i>	S	D	0.02	0.00
<i>Phleum pratense</i>	G	M	0.16	0.00
<i>Plantago alpestris</i>	H	D	0.92	0.84
<i>Poa costiniana</i>	G	M	34.04	41.36
<i>Poa fawcettiae</i>	G	M	1.78	3.76



## APPENDIX I

<i>Poa hiemata</i>	G	M	10.24	18.60
<i>Poa pratensis</i>	G	M	0.60	0.04
<i>Polystichum proliferum</i>	F		0.16	0.00
<i>Prasophyllum alpestre</i>	H	D	0.08	0.08
<i>Prostanthera cuneata</i>	S	D	0.34	0.60
<i>Ranunculus</i> sp.	H	D	0.04	0.00
<i>Richea continentis</i>	S	D	0.28	0.08
<i>Rytidosperma</i> sp.	G	M	0.14	0.12
<i>Scleranthus</i> sp.	H	D	0.00	0.04
<i>Senecio</i> sp.	H	D	1.82	0.04
<i>Stellaria pungens</i>	H	D	0.40	0.04
<i>Stylidium</i> sp.	H	D	0.06	0.00
<i>Taraxacum officinale</i>	H	D	0.00	0.04
<i>Trifolium repens</i>	H	D	0.10	0.04
<i>Viola betonicifolia</i>	H	D	0.12	0.00
<i>Wahlenbergia</i> sp.	H	D	0.70	0.24